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The Brain and its Relation to the Phenomena of Consciousness.

BY C. A. RAYNE, M.B., LOND.

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The Brain and its Relation to the Phenomena of Consciousness.

BY C. A. RAYNE, M.B., Lond.

I HAVE somewhat reluctantly, and in fact only under considerable pressure, consented to bring a paper before your notice this evening, because I very much doubt my ability to interest an audience like the present. The subject however is one of great interest, and being closely connected with my own department of thought and work, I may, perhaps, be able to put before some of you facts and considerations more or less novel, and not unworthy altogether of your attention.

The subject of the present paper embraces the connection and mutual relationship subsisting between body and mind. There was a time, and that not very long ago, when the mind was regarded as a something having no relationship of this kind, possessing and inhabiting a sphere of its own, entirely apart from all material influence. And even now it is not unusual to hear the somewhat mocking question addressed to physiologists who from brain structure endeavour to decipher the corresponding mental states, or the reverse. What has man's mind to do with brain matter? Can any knowledge of the spirit of man be gained through a scrutiny of nerve fibres and nerve cells?

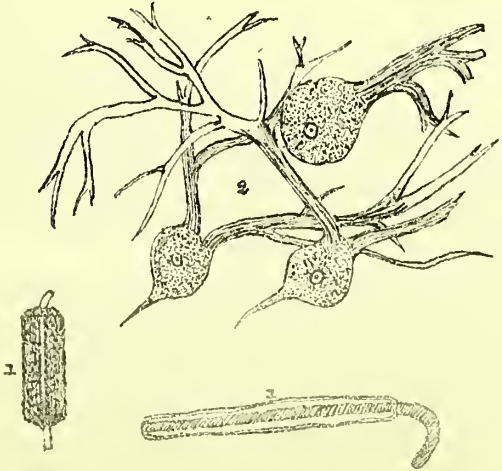
This is a most important question, and one which we shall see is fraught with great consequences in human development and happiness. The present state of our physiological knowledge is such as to warrant me in giving a distinct answer in the affirmative, and saying, Yes! facts and laws of great and increasing importance regarding man's mental nature and the methods of developing it in the best directions, can be arrived at from a scrutiny of the cells and fibres of his brain.

Some people shrink from this conclusion from a vague fear of drifting into materialism, from a vague fear that if the explanation of mental phenomena can be educed from physical, if mind can be always, so far as we know, shown to be connected with nerve currents in the brain, and *vice versa*, there is an end to the doctrine of an immaterial soul. They need however have no such fear, for though physiology may show us a wonderful correlation between physical changes going on in the brain and corresponding mental states, the one is in no degree *an explanation* of the other. The ultimate fact of consciousness remains as inexplicable as any other of the ultimate facts of nature. Perhaps I shall more clearly put my meaning before you if I take an illustration, I think from Professor Tyndall. Supposing the emotion of love to be associated with a right-handed rotation of certain brain molecules, and the emotion of hate to be associated with a left-handed rotation of the same—then we must admit that the emotion in question would invariably follow a molecular movement of the kind stated, no matter by what means excited. To regard the molecular movement as an *explanation* however of the mental state, is an impossibility. The two sets of phenomena are of an entirely different order, and the human imagination utterly refuses to bridge the gap between them, so as to regard them in the light of cause and effect. The human mind does not possess that faculty, nor the germ of any faculty capable of forming any distinct conception whatever of the nature of the union between the physical conditions and the corresponding facts of consciousness. One point however I would thus early draw your attention to, viz., that precisely the same reasoning applies to the consciousness which we can have no doubt exists in many of the lower animals, that their mental states are as inexplicable as our own from purely physical data, that we must stand or fall together in this respect, and that the commonly received opinion that man is distinguished from all other animals by being the only possessor of an immaterial part, a so-called soul, is scientifically and logically quite untenable. The difference between human and other animal consciousness is one of degree only, not of kind, and whatever reasoning applies as to the nature of the one applies with equal force as to the nature of the other. And I am the more unwilling to let the matter pass without remark, because I believe that an opposite view has sometimes been productive of much cruelty and injustice to our lowly relatives ; and when we find a man in the position of a great moral and religious teacher, like Cardinal Manning, saying publicly that man has no moral duties to the lower animals, because they possess no soul, and condemning cruelty to them only on the ground of injury to the higher qualities of his own nature, I think it as well to point out the other side of the question. Of course we must all admit a vast preponderance of conscious phenomena in the case of man, but to allow that consciousness even in its lowest phases can be the direct result of purely physical and material conditions appears to me to be, at least scientifically, fatal to a belief in its distinctly immaterial quality in ourselves.

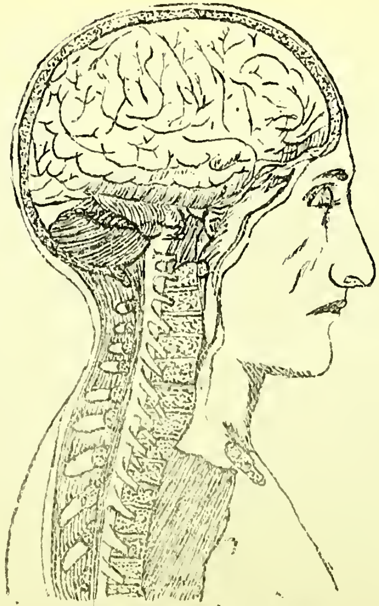
Before proceeding further, it will be necessary to call your attention to the general structure and arrangement of the nervous system in man and the higher animals. This nervous system consists of a large mass of nervous substance called the brain, lodged in the cavity of the skull, of a prolongation of this down the bony cavity of the back, called the spinal cord, and of various so-called nerves which extend from these as centres into all parts of the body. When we examine minutely, by means of the microscope and other appliances, into the structural nature of this tissue of which brain, spinal cord, and nerves are built up, we find it to be entirely resolvable into two sets of elements, entering into its composition in varying proportions in different parts. These are nerve fibres and nerve cells.

A *nerve fibre*, of which this is a diagram, of course on an immensely magnified scale, is a kind of tube (and is in fact often spoken of as a nerve tubule) having in its centre a fine axis, called the *axis cylinder*, which is as we shall see by far the most important part, consisting in chemical nature of an albuminoid or protein substance, of protoplasmic character. This, chemically, is resolvable into the four elements carbon, hydrogen, oxygen and nitrogen, with a trace of phosphorus and sulphur. Around this axis is a moderately thick coating of fatty matter, called from its discoverer, the white substance of Schwann, and the whole is invested with a delicate protecting membrane, the neurilemma. The real intrinsic part of the nerve fibre is the axis cylinder, or interior protoplasm, and the office of the investing fatty layer is simply to act as a non-conductor or insulator, and prevent the nerve current from passing to other fibres. For the nerve fibre is strictly analogous in constitution to an ordinary insulated electric telegraph wire—its office is to conduct impressions from one part of the body to another. The axis cylinder is the real conducting part and the office of the outside white substance of Schwann is like that of the gutta percha round an electric cable wire, simply to prevent the current from passing off sideways in other directions than the one intended.

And now for the *nerve cells*, of which this is a diagram. They may be described as little bags made of thin membrane and containing within them a similar but modified protoplasmic matter to that of the axis cylinder of a nerve fibre. The offsets from them join with other cells, or with axis cylinders of fibres, some with two fibres, some with three or more. Thus every cell in the brain may be said to be in connection with every other cell there, directly or remotely, and indeed it may be said to be in nervous connection with every part of the body. These nerve cells are the real originators of that nerve force of which the fibres are mere conductors. They are strictly analogous to the galvanic batteries which originate an electric current.



1 Nerve fibre showing axis cylinder.
2 Nerve cells and connections



Brain and upper part of spinal cord
of man.

The next point for our consideration is the arrangement in the nervous system of these two elements, nerve fibres and nerve cells. I have here a diagram of the nervous system in man. The brain, to which I will first direct your attention, is a large mass of nervous matter weighing about 3lbs. on the average, and contained in the cavity of the skull, where it is carefully protected from injury. It may roughly be divided for purposes of description into three parts. The outer surface, which is thrown into folds or convolutions, is of a grey colour, and consists almost entirely of cells and their connections, the active originators of nerve force. I shall henceforth refer to this as the cerebrum. It is here in all probability that consciousness really resides. The cells are computed to number some 800 millions, and the intensely complicated system of molecular movements going on in this enormous aggregate, during active thought, may be better imagined than described. The folds or convolutions are simply for the purpose of affording greater room for these surface cells and their connections. The higher the intelligence of the man, the more complicated are the convolutions of this part of the brain, and in the lower animals it is convoluted not at all or but slightly. Beneath this and occupying the central part of the brain is a mass of white matter, which is exclusively made up of nerve fibres, the merely conducting part. These connect the cells at the surface with the lower part or base of the brain and with the spinal cord. The base of the brain again consists of grey or cellular matter. These cells, however, differ somewhat in structure from those at the surface, and are arranged not in a uniform folded sheet, but in agglomerated masses, in pairs. They are called the *sensory ganglia*, and are for the purpose of receiving the several impressions of the senses, the eye, the ear, the touch, the taste, the smell, and bringing them into relation with each other and with the cerebrum and spinal cord. Each pair of the sensory ganglia sends off a bundle of white conducting fibres to the organs of the several senses: the eyes each receive a bundle, the optic nerves; the ears each receive a bundle, called the auditory nerves ; the nostrils each receive a bundle, called the olfactory nerves ; the sides of the tongue and throat each receives a bundle, called the gustatory nerves, or nerves of taste ; whilst another large bundle on each side proceeds to the spinal cord to be distributed to the body generally. Each pair of sensory ganglia has its own special sense to deal with.

The *Spinal Cord* passes down from the lower part of the brain and is continued down the back bone. It consists principally of conducting fibres from the brain, some of which, the *motor* or *efferent* fibres, conduct impressions from that organ to the various muscles of the body to produce movements, whilst other fibres, termed *sensory* or *afferent*, convey sensations upwards to the brain from all parts of the body. Both sets of fibres decussate or cross over to the opposite side in their progress to the body, and this is the reason why an injury to the brain on one side produces paralysis of the opposite side of the body. In addition to the conducting fibres of the spinal cord, it possesses in its interior a tract of grey cellular matter running throughout its length. This is for the purpose of originating nerve force independently of consciousness altogether, to supply the muscles which are required to act without the intervention of consciousness, as for instance during sleep. For muscular movements of the most complicated nature, involving the greatest nicety of adjustment between whole systems of muscles, may be performed quite unconsciously and by pure automatic mechanism in the nerve fibres and cells and the muscles concerned. This is a most important fact, and I ask you specially to note it—pure automatic performance of the most complicated acts without any consciousness of them. As instances of this, I may refer to many habitual acts performed during sleep (deep, unconscious sleep), such as breathing, coughing, and even sneezing, each of which requires an elaborate system of muscles, acting in due order, for its performance. But in addition many of our acts whilst awake may be quite unconscious ones when the attention is drawn elsewhere, as walking in a reverie, or the movements of the eyeballs when following a column of printed matter. Such acts are termed reflex, or automatic, and are largely regulated by the cells of the spinal cord.

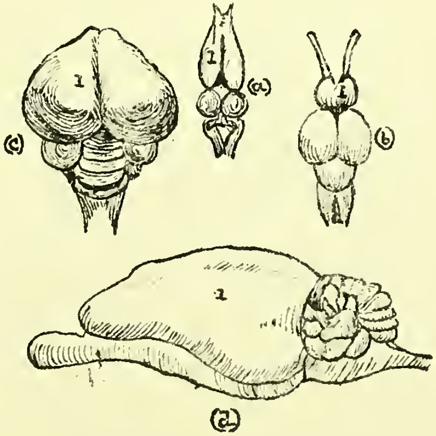
The spinal cord is brought into nervous connection with the several parts of the body, by means of the nerves which branch off from it on each side, and of which there are 31 pairs. These ramify over the body generally, the motor nerves going to the muscles, which they are able to excite to contraction and movement, the sensory nerves, or nerves of feeling, going to the skin and other parts. Within the limits of a paper like this I shall not have time to describe the several modes of their termination, which are however extremely interesting and suggestive. What is called a nerve is simply a bundle of nerve fibres running along parallel to each other. There are usually many thousands of such fibres in a nerve, for the average diameter of a fibre is but the eight-thousandth of an inch, and that of the axis cylinder or acting agent only the fifty thousandth of an inch, roughly speaking. Each fibre from its point of origin in a cell to its termination never divides or joins another ; if it did so the message which it is its office to convey might branch off and go to the wrong place. It is as though a large number of telegraph wires were running along in the same bundle, all carefully insulated, so that the electric current in one could not pass to any other, and thus ultimately carry the message to the wrong place. There are certain diseased conditions, in which the insulating medium, the white substance of Schwann, becomes destroyed, and thus allows the axis cylinders of a whole group of nerve fibres to communicate, and then the unfortunate sufferer ceases to have adequate control over certain groups of his own muscles, and his movements become spasmodic and irregular.

I have spoken of the force originating in a nerve cell or group of cells, and traversing a fibre, as a "current," and drawn an analogy between such a force and that of electricity originating in a cell or group of cells of a galvanic battery and passing along a wire. I should like to explain my meaning more fully. What is meant by a "current" of electricity is now considered to be undoubtedly, as you are no doubt aware, simply a wave of molecular disturbance which passes from one end of a conducting wire to the other in circuit with prodigious velocity. It is a current of motion passed rapidly on from particle to particle, and not one caused by the actual transference of material from one point to another, and necessitates a certain separatedness allowing free movements between the particles or "molecules" of the conducting medium. If such freedom of movement in the required direction does not exist we have an electrical non-conductor. Of course these ultimate particles, atoms, or molecules are so minute as to be a thousand times beyond the reach of the most powerful microscope to discover. It is practically certain however that they exist, and that even in a rigid body like a bar of iron they are continually in vibratory or other movement about each other, the vibrations being measured probably by millions per second, like the waves of light. A coarse illustration of this kind of molecular movement (but no doubt a very inexact one, for the real kind of movement can only at present be matter of guess-work) may be obtained by placing upright on end a series of books, one after the other, and at such a distance apart that each in falling may knock down the other. Then if the book at one end of the series be upset, it will in its fall knock down the next, and so the movement will pass on from one to another till it reaches the other end of the chain.

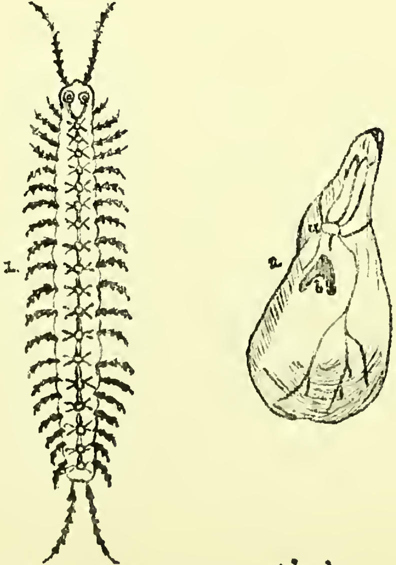
There are the strongest reasons for believing that the force traversing a nerve fibre, if not actually identical with that of electricity, is at any rate of very similar nature. The passage of electricity down a nerve is attended with all the manifestations of nervous force itself, muscles are made to contract powerfully as all will be aware who have grasped the conducting handles from a battery, and sensations of various kinds are excited. The greatest point of difference is in the velocity of the two, for whilst electricity, in the best conductors, will travel at something like a quarter of a million miles per second, nerve force travels only at something like 30 yards per second. Still, much of this might be accounted for possibly by differences in the nature of the medium traversed—in the one case a homogeneous metallic wire—in the other an animal substance, protoplasm, of the most complicated nature chemically.

The nervous system is continually giving out energy in the ways I have described, and in accordance with the established doctrine of the conservation of energy, of course requires some source from which it can re-supply itself. A steam-engine receives energy in the form of heat ; and is able to transmute a small portion of it into mass motion and mechanical work, though by far the largest proportion escapes as heat, and is for serviceable purposes wasted and lost. And if the supply of heat fails the engine stops. The nervous system obtains its supply of energy by chemical interaction with the particles of the blood which feeds it, but it is an engine which utilises all the energy it receives, and wastes little or nothing. The blood is conveyed to it as it is to other parts of the body, in a system of tubes, the arteries, which ramify amongst it, and break up into the finest tubules (the capillaries, about one three-thousandth of an inch in diameter). These capillaries form a close and intimate network throughout its whole substance, and ultimately are re-collected into large tubes (the veins), by which the blood returns to the heart. The amount of blood going to any part of the body may be taken as the measure of the amount of work that part has to perform. Now, the brain, which weighs only one-fortieth the weight of the whole body, actually receives no less than one-fifth of the whole blood supply of the body, and nearly the whole of this is concentrated upon the grey or cellular matter, which weighs but a few ounces, the white conducting fibres requiring but little. Some idea may be formed from this of the intense energy displayed by the cells. Now, as it is obvious that the brain or any part of it may be more active at one time than another, it is necessary that the amount of blood going to it should vary in accordance with its requirements at different times. For this purpose the nervous system is made self-regulating in this respect. The nerves themselves command the supply of blood going to all parts of the body in the following way : The arteries or tubes which convey the blood possess muscular tissue in their coatings, and certain nerves called vaso-motor or vessel-regulating nerves are set apart for action upon this muscular tissue. If more blood is required they cause the artery to dilate; if less, to contract in calibre. Perhaps the most familiar instance of this regulation of the blood supply to a part is seen in the act of blushing—a certain emotion in the mind excites the vaso-motor nerves of the arteries going to the cheeks; they relax and allow a flush of blood to go there. Similarly if any organ is called upon for increased activity, it receives an accession of blood. The lining membrane of the stomach which usually is pale has been seen to blush pink immediately that a supply of food has been placed in it. If we could but observe the varying color of different parts of the brain during different mental states, the problems of phrenology and of cerebral localisation of function would receive an immediate solution. In the emotion for instance of terror, certain parts would be observed to blush, in that of anger different parts. In attendance, say, at an opera, certain parts would be observed to be in unusual activity, or at a political meeting certain other parts. And conversely, if by artificial means we increase the supply of blood to a part, we increase its activity; if we decrease the supply of blood, we diminish its activity. Of course I am speaking of a normal, that is a pure and healthy, blood supply with its proper admixture of oxygen. If the blood is in an unhealthy or imperfectly oxygenated state, the problem becomes much more complicated.

Although my time is very brief and I dread being tedious, I must now, in order to an adequate comprehension of my subject, attempt to give a short exposition of the nervous system throughout the animal kingdom, first premising that in all cases we have the same two elements to deal with, viz., nerve cells and nerve fibres, and that these are of the same character in every animal as in ourselves, the difference in various animals being due simply to varying amount of nervous matter, and to varying complexity in its arrangement. The lowest forms of animal life verge upon



Brain of (a) Frog, (b) Fish, (c) Pigeon,
(d) Rabbit.
,,
1, is the Cerebrum.



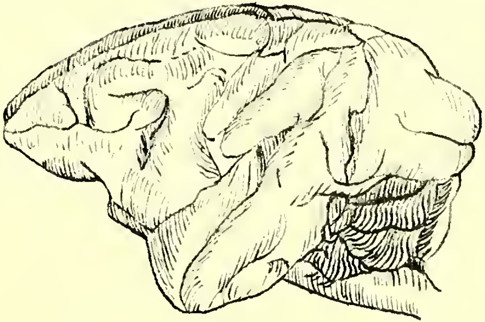
(1) Nervous system of centipede.
(2) Nervous system of lower mollusk.
(a) ganglion, (b) mouth.

the vegetable kingdom, and are mere bits of living protoplasm without any distinct trace of nervous system. The earliest forms in which a distinct nervous system is traceable is probably in the mollusks. Here we have one central mass of nerve cells, a so-called ganglion, with radiating fibres some of which are afferent, bringing impression to the cells, other efferent, conducting impression and nervous impulses from them. In the lower mollusks, the fibres are almost exclusively connected with the stomach of the animal. If any improper material gain access to the stomach it excites an impression on the afferent fibres which is conveyed to the cell mass; this sends down an impulse to the muscles of the stomach, exciting them to contraction, and thus expelling the offending substance. The act is entirely reflex, and is unattended by consciousness unless in the lowest and vaguest form. We need have no compunction on the score of cruelty in swallowing an oyster alive. It is practically an unconscious animal mechanism.

A higher stage is reached in the articulata, which class includes insects, earthworms, and crustaceans, as the shrimp, crab, and lobster. Here instead of one single central mass of cells we have several pairs of such masses, placed in relation to the several pairs of limbs, over which they have respectively the control. The cellular masses (ganglia) are also connected with each other. There is usually a larger ganglion in the head of the animal connected with more or less perfectly developed eyes and in some cases ears. This may be called a brain, but is not to be considered homologous to a human brain. The more highly developed the animal (as the spider or lobster) the larger in proportion to the rest is the nerve centre for the head. These animals are very largely pure reflex mechanisms, not necessarily endowed with consciousness, though probably the higher of them possess it more or less vaguely. The caterpillar will continue to walk, and the earthworm to wriggle though divided into several pieces, in virtue of the nerve mass contained in each portion, but it is practically certain that each divided portion possesses no consciousness and feels no pain, unless we except the head piece, which probably has some vague and obscure sensations. Instinct itself, which is so wonderfully developed in the insect tribe as to simulate purposive and intelligent acts in a remarkable degree, is in the majority of instances only reflex action on a highly complicated scale, such as I shall have hereafter to refer to in the case of man himself, and is not necessarily attended by consciousness.

In the lower vertebrata, or back-boned animals, fishes, we for the first time meet with a nervous system consisting of brain, spinal cord, and system of nerves as in man, and this arrangement persists in the other vertebrate classes, of reptiles, birds, and mammals. In fish the part of the brain corresponding to the human cerebrum, where consciousness resides, is extremely small, though the sensory ganglia, especially those connected with vision, may be well developed. Gradually as we ascend higher and higher in the vertebrate scale, the sensory ganglia lose their predominance, and the size of the cerebrum proportionally increases. The proportionate size of the cerebrum determines the position of the animal in the scale of creation. In birds it is already larger than all the rest of the brain put together, in the lower mammalia (rat, rabbit, guinea-pig) it has about the same development, and the sensory ganglia for the sense of smell become also very highly developed. When we get to the dog and the cat, we find the grey matter of the cerebrum in such excess as to necessitate its being thrown into folds or convolutions to accommodate it, and in the monkey these convolutions are more complicated, and distinctly foreshadow in their shape and position the condition in the case of man himself, and in fact in the highest or anthropoid apes they are little distinguishable from those of the lowest races of mankind, except perhaps in general size and development.

In the further remarks I have to make, I wish to direct your attentive consideration to the three classes of nerve centres I have now discussed : Firstly, the grey cells of the cerebrum or brain proper with their complicated system of connections with each other and with the centres below them, 1



(1) Brain of a monkey.

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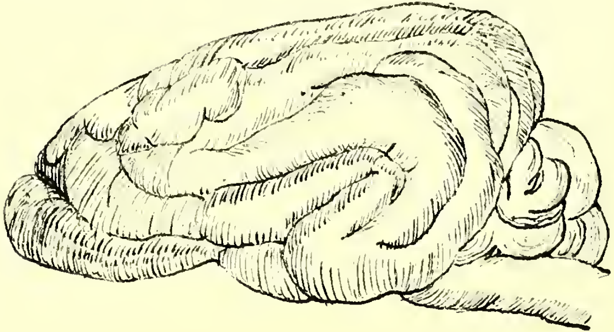

(2.) Brain of a dog

Cerebrum being nearly all that is visible.

and where I have localised consciousness ; Secondly, the cells of the various sensory ganglia, connected with the special senses and also with each other, and the spinal cord ; Thirdly, the cells of the spinal cord itself with their connection with each other and with all parts of the body by the system of nerves.

I have shown that the cells of the spinal cord can take upon themselves, under appropriate stimulus, acts of a very complicated nature, in a purely reflex or mechanical manner, as breathing, coughing, sneezing during sleep, without the intervention of consciousness, each of which acts, if carefully studied, is found to involve the co-ordinated and accurately adjusted action of several systems of muscles. This independent action of the spinal cord is found to increase as we descend the animal scale, that is, as the cerebrum decreases in development. Thus, in a frog with its head cut off the body is capable of apparently very purposive acts. If touched it will jump away ; if a portion of the skin be irritated, it will use one leg to rub the place ; and if that leg be tied fast it will use another. If thrown into water it will swim. It may be said that this is proof of consciousness in its spinal cord, but the weight of evidence lies against this view. Thus in a man who, by disease or injury, has had his spinal cord destroyed at a certain point in the upper part of his back, so that all sensation in the part below the seat of injury is abolished, if his foot is pinched or pricked he will withdraw it, and if his eyes are turned away he will be quite unconscious not only of the irritation, but of the fact that his leg has moved.

But, further, I proceed to state that the sensory ganglia themselves, though not necessarily, yet probably, unconscious centres of activity in the lower animals, are so in ourselves. These sensory ganglia are connected with the special senses, and are capable of receiving their impressions, and, so to speak, acting upon them in the most complicated and apparently reasoning manner without a vestige of consciousness. You may say this is impossible. I can answer that even in coarse human machines a certain amount of apparently purposive action may be devised, as in a steam engine, which opens its valves at the proper moment to admit steam on one side of the piston, and at the proper moment shuts them and opens others on the other side. I may further remind you that each sensory ganglion consists of millions of cells and connections, and what is not possible to them? But further, I have proof to offer. In somnambulism, or sleep walking, the cerebrum, the conscious centre, is profoundly asleep and inactive, but the sensory ganglia are all awake though unconscious. And what do we observe? A man (or woman) will arise from bed, carefully avoid every obstacle, open the bedroom door, descend the stairs carefully, grope his way in the dark, perhaps do something that he has previously set his mind on, and return to bed. In the morning he is unconscious that anything has been done. I am aware that in sleep-walking a man may be conscious, as in a dream, of what he has done owing to his cerebrum being partially awake, but in a large number of cases there is no consciousness at all. I have had lately under my care a patient suffering from sleep-walking in its most exaggerated form, both by night and day. She would rise from her bed or couch, and act apparently in the most reasoning manner; she would appear to watch till her nurse had left her side before she attempted to move; if tied in bed, she would take a pair of scissors from her work basket and cut the strings that bound her. And yet on coming round from her condition she had not the slightest consciousness of anything that had transpired. This shows the automatic power resident in the sensory ganglia. If we could see her brain during these manifestations, I have no doubt we should see her sensory ganglia flooded with blood and all alive, whilst her conscious cerebrum, was pallid and inactive. Yet another instance. A young man from a distant town, some time ago, consulted me, who was subject to occasional epileptic attacks. Such attacks, which are the result of nerve cells discharging themselves inopportunely, so to speak, are the sign of an unusual state of the nervous centres. He was tall, muscular, and athletic, and the captain of a football club. He told me that during a match, in which he had joined a few days previously, he suddenly became unconscious, and yet played on. He saw a man take out his watch and cry out "ten minutes to time to close," and after that had no consciousness until he found himself at the end of the game, lying in a corner of the field with anxious friends around him. He had played during those ten minutes exactly as though he were conscious, and had, in fact, taken a leading part in the game. He had two brothers on the field who corroborated his statement, and said he played exactly as usual until the end of the game, when he quietly withdrew himself to a corner of the field and laid down, as though tired or ill. What extraordinary light does this one case afford to our view of unconscious and automatic phenomena generally! and it comes almost as a revelation to interpret to us many kinds of instinct in animals. His eyes saw the football, his ears heard the cries of his companions, and acted on them, not intellectually and consciously, but in a complicated reflex manner. His cerebrum was pallid and inactive and unsupplied with blood, therefore he had no consciousness, but his sensory ganglia were wide awake and equal to the emergency though unconscious.

I will further add that, in explanation of mesmerism, little more need be added to what I have described. You are all, no doubt, aware of what is the chief plan of the mesmerist, who ought to have a strong and emphatic presence calculated to excite attention of a marked kind, in the mind of the mesmerised, who ought to be an individual of rather weak mind, easily subdued, or at least imaginative and emotional, and the less educated in physiological matters the better. The mesmerist endeavours to excite the closest attention to some particular object, his eyes, his movements, or a bright object held close to the patient's eyes. What follows? Whilst the faculty of attention in the patient's brain keeps all on the alert, together with his sensory ganglia, the rest of his brain gradually becomes inactive, the blood is withdrawn from it, and it sinks into sleep. But he is all alive to the voice and look of the mesmerist which have so engrossed his attention, and his sensory ganglia act implicit obedience to the voice of the charmer. But his will and intelligence are asleep and unconscious. He wakes either knowing nothing of what has transpired, or else having a dream-like notion of it, owing to certain of his cerebral centres not being quite unconscious, or having been aroused to more or less activity in the process.

Having now localised consciousness in man in the cells of his cerebral convolutions, there remains an enquiry of very great interest, but to which I can only briefly refer, viz., is there any evidence of a differentiation of consciousness, so that one conscious quality may reside in one part, and another in another part? In other words, does volition occupy a distinctly localised position as compared with reason and emotion? Up to within the last few years, no answer could be given to this question, many leading physiologists holding that in every distinct state of consciousness, the whole of the convolutions of at least one side of the cerebrum took part, whilst the phrenologist mapped the brain out in the most phantastical manner, and with scarcely a vestige of real scientific evidence, held the doctrine that each division had its separate function. In late years, however, Prof. Ferrier and others have solved the question by direct experiment on animals, and have added more to our knowledge of cerebral physiology than had been accumulated in the whole history of the world before, and many of his results are distinctly corroborated by observing the effects of accidental injury, or disease of different parts of the brain in man. I can only briefly refer to these experiments. The animals used were chiefly monkeys, as being nearest to the human type. As the brain itself is not sensitive, and does not feel pain when cut or wounded, and as the animals were carefully chloroformed during the operation, and after observation of the results killed by chloroform, we are not to assume that these experiments were necessarily very cruel. It may surprise you to learn that the brain substance, though the seat of consciousness, is not sensitive to injury, but, so far as we can judge, it is true. There are cases on record of injury to the head in men, where portions of brain have protruded, and have had to be cut off, but this has not caused any pain. The fact is that the brain can only be excited to consciousness by the proper nervous impulses coming up through the proper channels—the conducting fibres, and thus exciting to action the whole elaborate machinery.

The method adopted by Ferrier was to remove a piece of the skull and expose the portion of brain underneath, to stimulate this by a weak current of electricity and observe the effects. Then to cut out or destroy the same part, and observe the deficiencies of the animal on coming round. He has found that the front half of the convolutions is purely motor and the back half sensory. Thus on stimulating various points in front, various adaptive and highly complicated movements of the limbs were excited—there is a distinct centre for each kind of movement, and this corresponds in position for each species of animal examined. After removal of the centre, the animal was found on recovering from the effects of the chloroform, to be incapable any longer of that particular movement, though it could make others with the same limb. Could walk for instance just as well as ever. The exact co-ordination of a particular set of muscles for a particular purpose had been destroyed, though the muscles were not paralysed, and could act quite well for other purposes. The hinder or sensory convolutions were found to contain centres for each of the special senses. Thus on stimulating a particular part, the centre for vision, the animal showed every manifestation of seeing something extraordinary, a flash of light, or something of the kind. The centre was cut out, and on recovery from the chloroform it was found to be blind, though its eyes remained quite healthy in appearance. Similar centres were found for the other senses.

Ferrier deduces from these observations that the back half of the cerebrum is alone the seat of consciousness; first of sensations derived from the senses, then of the corresponding emotions which have been built up upon these sensations.

He further considers that in every intellectual act the whole of the cerebrum comes more or less into play; but into the elaboration of his argument time will not permit me to enter.

I may here state that the discoveries of Ferrier and others on the localisation of brain function have received practical confirmation of a very encouraging kind. Formerly, tumours of the brain were always considered fatal. Within the last two or three years, however, their position has been capable of precise determination in several cases, from the irritation of the particular cerebral centres involved leading either to anomalous sensations, or to convulsive movements of certain groups of muscles, and they have been operated upon surgically, and removed, with, in several instances, complete recovery of the patient.

Whenever a nerve current traverses a particular part of the cerebrum, it leaves behind it a slight trace making it more easy for a current to pass the same way again. This is the basis of memory, without which all knowledge would be impossible. When I call to mind, for instance, the image of some object, as a dog, a faint current is then actually passing through my cerebral visual centres of precisely the same character as was originally excited by the sight of the object itself, but much weaker. In some cases this current may become as strong as the original current, then we get a spectral illusion, of which there are many cases on record, a person believing that he sees what does not really exist. Similarly the other sensory centres are capable of illusion.

The fact that a nerve current finds it more easy to traverse an old pathway is also the basis of habit and of bias. Ways of thought and ways of action that have been long indulged in, become so to speak organised in the cerebral structure, and cannot well be rooted out. It thus becomes difficult or impossible for one brought up for instance in a particular political or religious creed to receive with any appreciation the views of opponents, or to do justice to them. And we may well have scientific bigots too. It is stated that when Harvey first discovered the circulation of the blood, though he was able to bring proofs which appear to us now of the most convincing nature—yet none of the physicians of that day, who were over 40 years of age, were able to receive his views, having been bred up with very different ideas.

On the same principle is explained the fact that old people are apt to lose their memory for recent events, though the events of their earlier years continue very clear and distinct to them, having become by repeated thought organised in their cerebral tissue. By the term organised I simply mean that particular pathways have so frequently been used by nerve currents that they readily fall into the same pathways again. How important therefore it is that the early years of life should be happy and free from gloom—this is the best preparation for a cheerful old age. The poet Cowper, who passed a miserable boyhood, never lost the melancholy tinge through the whole of his after life, whilst the poet Wordsworth, happy as a boy, was one of the most cheerful and contented of old men.

We know that when a man's eyes are destroyed he can no longer see. He would still however be able to recall in memory his previous visual experiences, by means of the faint currents excited in his visual centres. But supposing these visual centres themselves destroyed, he would not only be blind, *but as though he had never seen.* The very idea of light or of seeing would be devoid of conception to him, and he could no longer form any idea of its nature. It would be like the conception of a fourth dimension in space to ourselves, which some mathematicians believe in but which is utterly beyond our grasp. May it not be possible that if we had a sixth sense centre, many things which appear to us now so mysterious would be made plain, and that even the nature of the connection between body and mind, which has puzzled so many philosophers, would be at length solved?

Although this question must then be regarded as an insoluble one so far as our present faculties will take us, it is interesting to note the direction in which attempts have been made at its solution by many of our leading thinkers, and this I will briefly refer to in conclusion.

One class of thinkers assume as a possible mode of solution, that all motion throughout the universe is vaguely conscious in a very faint degree, that the movements of the wind, of the ocean, and of the planets in space are faintly conscious; but that it is only when that motion becomes concentrated and elaborated in complexity, as it is in the cells of the cerebrum, that that consciousness can reach the pitch of being conscious of itself so to speak, or self-conscious. According to this view, motion and consciousness are synonymous terms, are identical in reality, but the one is objective or externally observed, the other is subjective or internally perceived. Thus if we could actually see the movements going on in the molecules of a man's brain during active thought, what to us as outsiders would appear only motion of an intensely elaborate and complicated character, would to him be felt subjectively as consciousness. In support of this view it may certainly be pointed out that consciousness is most intense where nerve currents are forming new pathways and where there is therefore a greater amount of friction so to speak, and that in proportion as what I have termed organisation of cerebral pathways becomes complete, consciousness more and more subsides, so that the action may become in time purely automatic without consciousness. This is the reason why new pleasures and new pains have an intensity that subsides on repeated experience, and why novelties of all kinds arouse so much greater interest than what is common.

Another class of thinkers adopt what we may term the doctrine of concomitancy, and consider that the varying states of consciousness and their corresponding physical conditions run along in close parallel lines without the slightest interconnection. This, though with our present faculties the only possible view apart from the one I have described, appears to me to reduce itself to an absurdity. For it involves that all that we think is a simple coincidence of all that we do, without the slightest interconnection. If I for example knock a man on the head and produce insensibility that insensibility is a mere coincidence and not in any way actually connected as cause and effect with my act. According to this view also I have no right to assume that you my auditors are conscious agents, you may be simply machines—and you have no right to assume that I am a conscious speaker—I may be simply a lecturing automaton. All that you or I can be really sure of is our own conscious existence and nothing else. If carried out into strictest logic, no doubt I could not prove that you were other than machines, or you that I was—but yet common sense comes in and shows a *reductio ad absurdum* otherwise. I was surprised to find that in a recent lecture before the Royal College of Physicians, London, Prof. Hughlings Jackson (one of our leading thinkers on nervous subjects), adopted the doctrine of concomitancy, and claimed as co-disciples such men as Spencer, Huxley, Bain, and Tyndall.

But all this only shows the extreme difficulty of coming to any absolute conclusion in the matter with our present faculties. As I read Prof. Huxley, he gives the matter up as inscrutable, and he is one of our clearest and deepest thinkers. He says, " how it is that a state of consciousness comes about as the result of irritating nervous tissue is just as unaccountable as the appearance of the Djin when Aladdin rubbed his lamp."

I will conclude by giving in his own words the views of Prof. Bain, as set forth in his work on " Mind and Body." " We have," says he, " every reason for believing that there is in company with all our mental processes *an unbroken material succession*. From the ingress of a sensation to the outgoing responses in action the mental succession is not for an instant dissevered from a physical succession. A new prospect bursts upon the view ; there is a mental result of sensation, emotion, thought, terminating in outward displays of speech or gesture. Parallel to this mental series is the physical series of facts, the successive agitation of the physical organs. While we go the round of the mental circle of sensation, emotion, and thought, there is an unbroken physical circle of effects. It would be incompatible with everything we know of cerebral action to suppose that the physical chain ends abruptly in a physical void occupied by an immaterial substance; which immaterial substance, after working alone, imparts its results to the other edge of the physical break and determines the active response—two shores of the material with an intervening ocean of the immaterial. There is in fact no rupture of nervous continuity. The only tenable supposition is that mental and physical proceed together as undivided twins. When, therefore, we speak of a mental cause, a mental agency, we have always a two-sided cause; the effect produced is not the effect of mind alone, but of mind in company with body."